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This report was designed to present an example of a research study involving the use of coefficients of orthogonal comparisons in analysis of variance tests of significance. A sample research report and analysis was included so as to lead the reader through the design steps. The sample study was designed to determine the extent of attitudinal changes in industrial education and home economics student-teachers due to the effects of the attitudes of their supervising teachers. The Minnesota Teacher Attitude Inventory was administered in a pre-and post-test design. Scores from the post test and the difference between pre-and post-test scores were utilized in the analysis. Attitude scores were collapsed into four levels and the students' fields were considered as two levels of an educational factor in a 2 by 4 design. (EM)

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ATTITUDINAL CHANGES IN THE STUDENT TEACHER - A FURTHER ANALYSIS

AN EXAMPLE OF AN ORTHOGONAL COMPARISONS ANALYSIS MODEL APPLIED TO EDUCATIONAL RESEARCH

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FOREWARD

The primary purpose of this report is to present a research design representing an example of the use of orthogonal comparisons in the analysis of variance sequence of significance testing. The problem presents a practical usage for this design approach and relates it directly to the education situation. Practitioners as well as theorists should be quite easily lead through the design steps as they read the report. The complete analysis is included for this purpose.

For the graduate student in education or psychology, the design here presented may prove quite useful. The model here presented could quite easily be adapted to similar factorial experiments. In any event, it may be used as an example to be followed in developing related research.

EWC

ACKNOWLEDGEMENTS

The author is grateful to all of those teachers who contributed the data necessary for the study analysis. The author is likewise indebted to Dr. John K. Coster of the University of Nebraska for his technical advice and counsel in the formulation of the design for the study.

E. Wayne Courtney

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U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION

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by

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CHAPTER I

Introduction to the Study

I. STATEMENT OF THE PROBLEM

The central problem of this study was to determine the extent of attitudinal change in the student teachers as influenced by the attitudes of their supervising teachers. Students utilized for the study were college education majors who were categorized according to type of education or group program and by their supervising teacher attitude scores. The problem involved the following major premises:

1. the selection of an instrument which would properly measure attitudes and which could be used to indicate changes in attitudes.

2. the administration of the selected instrument to an identified population of student teachers and their supervising teachers.

3. the statistical analysis of the collected data to determine the presence of or lack of significant attitudinal changes and interaction effects.

4. the formulation of implications for curriculum planning activities and teacher training.

II. THE DEFINITIONS

The following terms or phases as used in this report are hereby defined; other terms appear to be self-explanatory.

1. <u>Attitude Score</u> refers to that raw score which

a student teacher or supervising teacher received on the Minnesota Teacher Attitude Inventory.

2. A Supervising Teacher is a regular, full-time, certified teacher employed by an accredited public school system in Wisconsin and who has been contracted and assigned by the state college system to supervise student teacher activities.

3. Type of Program or Group refers to the type of student teacher program which is being pursued by those individuals utilized for the study. For this study, Home Economics Education and Industrial Teacher Education majors were used.

III. BACKGROUND OF THE PROBLEM

The primary literature impinging upon the present problem is that which has been reviewed in a previous report and that which the previous study reported.[1] That study developed a rationale for the analysis of variables in the teacher training area and developed a review of the factors of morale, intelligence, and attitudinal change for the student teacher.[2] In analyzing the results of this study by the present author, it would appear that the

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[1] E. Wayne Courtney, Attitudinal Changes in the Student Teacher, Department of Psychology and Education, Stout State College, Menomonie, Wisconsin, 1964.

[2] Ibid.

factors of intelligence of the student teacher and the morale level of the supervising teacher have little effect upon the subsequent outcomes of attitude change for the student. It seems rather conclusive that the only significant positive factor identified as a result of this study was the group, and consequently, sex difference since the study involved a complete male population in one group and a complete female population in the other group. The conclusion specified that curriculum planners in education might consider the more autocratic attitudes of male students, as shown by the results of the study, when training teachers in the acquisition of democratic attitudes.[3] Likewise, perhaps male students should be given more experiences in attitude formulation than are presently contained in their training sequence.[4]

Other studies have shown that the supervising teacher plays a vital role in the emerging attitude pattern of the student teacher.[5] This research alone provides sufficient rationalization for studying the attitudes area as it pertains to the training of teachers.

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[3]Courtney, loc. cit., p. 28.

[4]Ibid.

[5]Owen Scott and Sterling G. Brinkley, "Attitude Changes of Student Teachers and the Validity of the Minnesota Teacher Attitude Inventory," Journal of Educational Psychology, 51:76-81, April, 1960.

IV. THE DIRECTION OF THE STUDY

For the present study the major interest was directed toward determining attitude change of student teachers as influenced by supervising teacher attitude. The bulk of the research up to this time has been directed toward the establishment of various elements which may effect attitude scores. Attitudinal change for the student teacher as related with the attitude factor for the supervising teacher has not previously been approached.

The plan for the present study was to analyze four supervising teacher attitude score levels as measured by the Minnesota Teacher Attitude Inventory and to compare these levels with scores obtained by student teachers on the same test. The study was designed to develop coefficients of orthogonal comparisons for the analysis.

The present research resolves into a problem with both teacher training and supervising teacher selection ramifications. The knowledge of the effects of the supervising teacher upon the student teacher is important both to the college teacher of education courses and to the college teacher training supervisor. The present study approaches the analysis of this situation.

CHAPTER II

The Design of the Study

I. THE VARIABLES

Where you find equal numbers of individuals in subclasses, you may partition the total sum of squares into component parts.[6] The problem is designed to utilize coefficients of orthogonal comparisons in the analysis. The study analyzed both the MTAI post-test score and the MTAI difference figure. The difference figure was the subtracted portion of the pre-test and post-test scores. Both analyses were made in order to give the researcher a more complete analysis of the problem.

II. THE INSTRUMENT

The Minnesota Teacher Attitude Inventory instrument used for this study was selected for the purpose of analyzing the attitudes of both student teachers and supervising teachers. The effect of the supervising teacher's attitude upon the student teacher's attitude was the primary consideration of the study.

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[6]Bernard Ostle, Statistics and Research (Ames, Iowa: The Iowa State College Press, 1954), pp. 142 ff.

III. THE EXPERIMENTAL DESIGN

The basic design for the study was an orthogonal comparisons design of analysis of variance, with two levels of the type of education factor and four levels of the supervising teacher attitude factor.

Sampling presented no problem in the study. A random selection of four students were selected from each of the four fixed populations studied.[7] The sampling procedure actually followed is described in a subsequent section of this chapter. The mathematical model for the analysis of variance was:

$Yijk = \mu + Gi + Aj + GAij + eijk$, where

μ is a fixed but unknown constant,

Gi is the differential effect associated with the type of education or group factor,

Aj is the differential effect associated with the attitude factor,

GAij is the differential effect associated with the interaction factor, and where

ijk is a random variable, normally and independently distributed about a mean of zero and a variance of σ^2.

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[7] A table of random numbers was used for all randomizations.

IV. THE SELECTION OF THE SAMPLE

For this study, a random selection was made resulting in the identification of four (4) individuals from each of four population cells as diagrammed below:

G_1

A_1	A_2	A_3	A_4
n_{111}	n_{112}	n_{113}	n_{114}

G_2

A_1	A_2	A_3	A_4
n_{121}	n_{122}	n_{123}	n_{124}

where,

n_{111} is the sample of four (4) individuals receiving training under the Industrial Education program (G_1) and whose supervising teacher's attitude score fell in section A_1,[8]

with the study basically concerned with orthogonally comparing the fixed factors which have been assigned.

The defined population represented Stout State University seniors who were majoring in education.

V. THE HYPOTHESES AND THE EXPECTED MEAN SQUARES

It has been stated previously that the primary con-

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[8]Sections were separated as follows: A_1 = -71 to -14, A_2 = -13 to + 23, A_3 = + 24 to + 50, A_4 = +50 to + 96. These separations were arbitrarily assigned by the investigator.

cern was to determine attitudinal change in the student teachers as influenced by the attitudes of their supervising teachers.[9] The major hypotheses to be tested were as follows:

1. there is no group effect.
2. there is no attitude effect.
3. there is no interaction effect.

Expected mean squares were derived for each of the sources of variation as follows:

Source of Variation	Degrees of Freedom	Mean Square	Expected Mean Square
Group (G)	1	A	$\sigma^2 + 16\phi_G$
Attitude (A)	3	B	$\sigma^2 + 8\phi_A$
Group x Attitude	3	C	$\sigma^2 + 4\phi_{GA}$
Within Cell Error	24	D	σ^2

From the expected mean squares, the appropriate tests of hypotheses were ascertained by evaluating the variances of the sources of variation appropriate to each hypothesis. Further information regarding tests of hypothesis is given below:

Hypothesis	df	F-test	α-level	Critical Region
1	1,24	A/D	.01	$F > 7.82$
2	3,24	B/D	.01	$F > 4.72$
3	3,24	C/D	.01	$F > 4.72$

[9] Supra, p. 1.

Further tests were made for the orthogonal comparisons as follows:

Source	df	F-test	α-level	Critical Region
$C_1(A_1$ vs. $A_2A_3A_4)$	1, 24	C_1/D	.01	$F > 7.82$
$C_2(A_4$ vs. $A_2A_3)$	1, 24	C_2/D	.01	$F > 7.82$
$C_3(A_2$ vs. $A_3)$	1, 24	C_3/D	.01	$F > 7.82$

Additional information has been developed in detail in the analysis section of this report. The appendix section likewise will be helpful to the reader in understanding the problem design and analysis.[10]

[10]See Appendix for an example of the problem computations.

CHAPTER III

The Analysis of the Data

Previously it was indicated that orthogonal comparisons would be used in the problem analysis. This section outlines the steps involved in using this procedure. The comparisons actually made were A_1 vs. $A_2A_3A_4$, A_4 vs. A_2A_3, and A_2 vs. A_3. These were the attitude category comparisons only. Tests were likewise made for groups, composite attitude, and interaction effects.

I. ORTHOGONAL COMPARISONS

Where you have equal numbers in the subclasses, you can partition the total sums of squares into component parts.* With "t" representing the treatment totals, if t - 1 comparisons are made among "t" treatments and if the comparisons are independent of each other, they are then called orthogonal sets. Orthogonality is defined for any two comparisons in terms of the coefficients.[11] Coefficients for orthogonal comparisons for this problem were determined in advance as shown below:

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[11] Cf. Robert G. D. Steel and James H. Torrie, Principles and Procedures of Statistics (New York:McGraw-Hill Book Company, 1960), pp. 213-220.

*See Ostle, op. cit., pp. 272 ff.

	A_1	A_2	A_3	A_4		
C_1	-3	≠1	≠1	≠1	so that	= 0
C_2		-1	-1	≠2	so that	= 0
and so for		(-3)(0)≠(≠1)(-1)≠(≠1)(-1)≠(≠1)(≠2)				= 0
C_3		≠1	-1		so that	= 0

With T_1 equalling the total of each treatment, so that each T_1 was summed over eight (8) observations (e.g., two groups with four individuals per cell), the following D values were derived:

$-3T_1$	≠	T_2	≠	T_3	≠	T_4	= D_1
	-	T_2	-	T_3	≠	$2T_4$	= D_2
	≠	T_2	-	T_3			= D_3

These D values were then used in computing the mean squares for each comparison with

$$C_1 = \frac{D_1^2}{8((-3^2)\neq(\neq 1^2)\neq(\neq 1^2)\neq(1^2))} = \frac{D_1^2}{96}$$

$$C_2 = \frac{D_2^2}{8((-1^2)\neq(-1^2)\neq(\neq 2^2)} \quad \text{or} \quad \frac{D_2^2}{48}$$

$$C_3 = \frac{D_3^2}{8((-1)^2\neq(\neq 1)^2)} \quad \text{or} \quad \frac{D_3^2}{16}$$

These values then acted as the mean squares, which, when divided by the appropriate degrees of freedom, and consequently by the error factor, produced the F test value. For the present problem these values did not change because the degrees of freedom for each comparison equalled one

(1).[12]

Tests for determining the significance of group effect, composite attitude effect, and interaction effect were derived from an analysis of variance which tested these factors. For this problem both post-test scores and difference scores (pre-test minus post-test scores) were used in the analysis and were compared for all factors studied.

II. THE ANALYSIS

The design called for the analysis of various attitude levels for the two groups studied. There were a total of eight combinations utilized for the study. These combinations were made arbitrarily by the researcher with all factors being considered as fixed.

The usual procedure was followed in the analysis of variance for the computations of mean squares for the group factor, composite attitude factor, and the interaction factor. The previously presented outline was followed for the orthogonal comparisons analysis.[13]

The post-test score was the score which was obtained on the Minnesota Teacher Attitude Inventory as the student teacher completed his off-campus practice teaching experience. This score was used in the first analysis with the

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[12]See the Appendix for the complete problem example.

[13]Supra, p. 12.

following table representing the analysis of variance summary.

TABLE I

THE ANALYSIS OF VARIANCE OF

THE POST-TEST SCORES

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Groups	1	20250.78	20250.78	27.68*
Attitude	3	6105.84	2035.28	2.78
$C_1(A_1$ vs. $A_2A_3A_4)$	1	2959.26	2959.26	4.05
$C_2(A_4$ vs. $A_2A_3)$	1	38.52	38.52	0.05
$C_3(A_2$ vs. $A_3)$	1	3108.06	3108.06	4.25
Group x Attitude	3	1996.85	665.62	0.91
Students Within Cells (Error)	24	17557.25	731.55	
Total	31	45910.72		

*Significant at the .01 level.

A second analysis involved the use of the difference score as the Y variable. The difference score represented the numerical difference between pre-test and post-test scores on the Minnesota Teacher Attitude Inventory. The pre-test score was administered immediately prior to the practice teaching experience. The difference factor was used to gain insight into the significance of changes in attitude for the student teacher. The following resume' (Table II) represents this analysis.

TABLE II

THE ANALYSIS OF VARIANCE OF
THE DIFFERENCE SCORES

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Squares	F
Groups	1	1212.78	1212.78	3.06
Attitude	3	471.34	157.11	0.39
C_1 (A_1 vs. $A_2A_3A_4$)	1	68.34	68.34	0.17
C_2 (A_4 vs. A_2A_3)	1	60.75	60.75	0.15
C_3 (A_2 vs. A_3)	1	342.25	342.25	0.86
Group x Attitude	3	3433.10	1144.37	2.88
Students Within Cells (Error)	24	9550.25	397.92	
Total	31	14667.47		

*No F values were found to be significant in Table II.

Thus, the results have been presented for both analyses. The results of these analyses will be discussed in the following section.

III. THE RESULTS OF TESTS OF HYPOTHESES

Because all variables included in this study were fixed, the results of tests of hypotheses for main and interaction effects were treated the same. The orthogonal comparisons analysis separated the attitude factor in comparing various levels with one another and as groups. An F test with more than one degree of freedom for the numerator mean square is an average test of as many independent comparisons as there are degrees of freedom.[14]

[14] Cf. Steel and Torrie, op. cit., pp. 214-15.

It is because of this fact that we use the orthogonal comparisons analysis. If only one of the comparisons involves a real difference and if this difference should be hidden when averaged with a number of nonreal differences, then the difference might not be detected at all. Because of this, we develop independent comparisons. This type of factorial experiment lends itself to the type of analysis here presented.

The following results of the hypotheses are presented below:

Hypothesis 3: There is no interaction effect, or H: GAij = 0.

The test statistic for the hypothesis was the F statistic and the critical region was $F_{.01\ 3.24} > 4.72$. The indicated test for the hypothesis was

$$F = \frac{\text{Interaction Mean Square}}{\text{Mean Square Error}}$$

When the interaction test was made, F was not found to be the critical region. Hence, the hypothesis was not rejected. This finding indicates that interaction differences between means were not present for the factors studied. Using both post-test scores and difference scores of Y produced the same results for this hypothesis.

Hypothesis 2: There is no attitude effect, or H: Aj = 0.

The test statistic for the hypothesis was the F statistic and the critical region was $F_{.01\ \ 3,24} > 4.72$.

The test for this hypothesis was

$$F = \frac{\text{Mean Square Attitude}}{\text{Mean Square Error}}$$

For this hypothesis, further tests were made for the following orthogonal comparisons: C_1 (A_1 vs. $A_2A_3A_4$), C_2 (A_4 vs. A_2A_3), and C_3 (A_2 vs. A_3). The test statistic was the F statistic and the critical region was $F_{.01\ 1,24} > 7.82$ for each comparison. The mean square error term was used for testing the comparisons hypothesis.

None of the comparison tests showed F to be in the critical region; therefore, the hypotheses were not rejected. This finding indicates that mean attitude scores were common for those categories studied when both post-test scores and difference scores were used as the Y variable. The comparisons tests indicated that there were no hidden differences for the attitude factor.

Hypothesis 1: There is no group effect, or H: $G_i = 0$. The test statistic for this hypothesis was the F statistic and the critical region was $F_{.01\ 1,24} > 7.82$. The indicated test for the hypothesis was

$$F = \frac{\text{Mean Square Group}}{\text{Mean Square Error}}$$

For this test, F was not found to be in the critical region when the difference score was used as the Y variable; however, when the post-test score was used, F was found to be in the critical region.

The analysis for this hypothesis concluded that differences existed between group means when the post-test

score was used but that no differences existed when the difference score was used as the Y variable.

CHAPTER IV

The Summary and Conclusions

I. RESTATEMENT OF THE PROBLEM

The central problem of this study was to determine the extent of attitudinal change in the student teachers as influenced by the attitudes of their supervising teachers. The problem involved four major premises:

a. the selection of an adequate attitudes measuring instrument.

b. the administration of the instrument to an identified population of student teachers and their supervising teachers.

c. the statistical analysis of the collected data to conform to a presented design.

d. the formulation of implications from the analysis of the data.

II. THE VARIABLES

This study analyzed the factors from two approaches, that of using the post-test score on the Minnesota Teacher Attitude Inventory as the Y-variable and that of using the difference score as the Y-variable. Those factors studied included attitude, group, and interaction effects with an orthogonal comparisons analysis being made for the attitude factor.

III. THE CONCLUSIONS

The present research was designed to study the influence of the supervising teacher's attitude on the attitude of the student teacher. The sampling procedure randomized from eight populations represented two group levels. Four individuals were selected from each of the eight defined cells. Based on the results presented in Tables I and II,[15] the following conclusions were drawn:

Conclusions Pertaining to Group Effect

1. When the hypothesis that group means were equal was tested, F was not found to be in the critical region when the difference score was used as the Y variable.[16] This test would indicate that no differences existed between group means when using this variable.

2. When the hypothesis that group means were equal was tested using the post-test score as the Y variable, F was found to be in the critical region and the hypothesis was rejected.[17] It was concluded that differences did exist between group means when testing the post-test score.

Conclusions Pertaining to Attitude Effect

3. When the F test was made for the composite attitude factor, the hypothesis was not rejected.[18] There-

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[15] Supra, pp. 14-15.

[16] Supra, p. 17.

[17] Supra, p. 17.

[18] Supra, p. 17.

fore, it was concluded that no differences existed for the composite attitude factor for those categories studied.

4. When the orthogonal comparisons tests were made, F was not found to be in the critical region.[19] Hence, the hypotheses were not rejected. The comparisons tests indicated that there were no hidden differences for the attitude factor.

Conclusion Pertaining to Interaction Effect

5. In the test made for interaction significance, F was not in the critical region. It was concluded that interaction differences between means were not present for those factors studied.[20]

IV. THE IMPLICATIONS

From the analysis of the results, certain implications are given which are believed to be of practical significance to the educator.

Implication for Curriculum Development

Curriculum development is here defined as the process of planning, organizing, and implementing curriculum change.[21] In terms of this definition, the following implications are offered:

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[19] Supra, p. 17.

[20] Supra, p. 16.

[21] E. Wayne Courtney, Some Statistical Correlates in Industrial Graphics--A Study of Knowledge and Experience Interrelationships, Department of Psychology and Education, Stout State College, Menomonie, Wisconsin, 1963.

1. When the difference score was analyzed, no differences were found to exist between group means. This implies that means for differences did not vary according to the type of program studied. This would indicate that changes in attitude were initially the same for both groups. Curriculum planners in education should consider attitude training for both groups when regarding this analysis.

2. When post-test scores were analyzed, it was found that means did vary. With the home economics group having higher mean scores, perhaps this group has developed more favorable attitudes as a result of their student teaching. In any event, planners should consider this variation between male and female students when training for the acquisition of democratic principles.

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APPENDIX

DATA AND PROBLEM EXAMPLES FOR COMPUTATIONS

(INDUSTRIAL EDUCATION) (HOME ECONOMICS)

(Post-Test Scores)

A_1	A_2	A_3	A_4	G_1	A_1	A_2	A_3	A_4	G_2	G_1
48 (98)*	-33 (17)	66 (111)	13 (63)	294	64 (114)	73 (123)	89 (139)	77 (127)	503	797
-26 (24)	27 (77)	11 (61)	10 (60)	222	48 (98)	10 (60)	61 (111)	75 (125)	394	616
-15 (35)	-5 (45)	13 (63)	36 (86)	229	29 (79)	87 (137)	103 (153)	23 (73)	442	671
-19 (31)	-10 (40)	-13 (37)	53(103)	211	17 (67)	56 (106)	98 (148)	51 (101)	422	633
188	179	277	312	956	358	426	551	426	1761	2717
					$T_1 = 546$	$T_2 = 605$	$T_3 = 828$	$T_4 = 738$	2717	

(Differences)

-7 (93)	-34 (66)	-2 (98)	12(112)	369	18 (118)	-6 (94)	3 (103)	-19 (81)	396	765
2(102)	-6 (94)	116 (84)	-48 (52)	332	-11 (89)	1 (101)	14 (114)	5(105)	409	741
-5 (95)	-38 (62)	-5 (95)	15(115)	367	-11 (89)	9 (109)	9 (109)	-22 (78)	385	752
-4 (96)	-51 (49)	-74 (36)	6(106)	277	-40 (60)	-6 (94)	-14 (114)	-16 (84)	352	629
386	271	303	385	1345	356	398	440	348	1542	2887
					$T_1 = 742$	$T_2 = 669$	$T_3 = 743$	$T_4 = 733$	2887	

*Because of negative values, + 50 was added to each raw score in computing the Post-test score analysis and + 100 was added to each of the difference raw scores. The second score (in parenthesis) represents that adjusted score.

COMPUTATION OF T's

(Post-Test Scores)

$T_1 = 546$

$T_2 = 605$

$T_3 = 828$

$T_4 = 738$

(-1638)

$-3\ (546) + 605 + 828 + 738 = D_1$

$533 = D_1$

$-\ 605 - 828 + 2(738) = D_2$

$43 = D_2$

$+\ 605 - 828 = D_3$

$-223 = D_3$

(Differences)

$T_1 = 742$

$T_2 = 669$

$T_3 = 743$

$T_4 = 733$

$-3\ (742) + 669 + 743 + 733 = D_1$

$-81 = D_1$

$-\ 669 - 743 + 2(733) = D_2$

$+\ 54 = D_2$

$+\ 669 - 743 = D_3$

$-74 = D_3$

COMPUTATION OF C's

(Post-Test)

$$C_1 = \frac{D_1^2}{96} = \frac{(533)^2}{96} = \frac{284089}{96} = 2959.260$$

$$C_2 = \frac{D_2^2}{48} = \frac{(43)^2}{48} = \frac{1849}{48} = 38.5208$$

$$C_3 = \frac{D_3^2}{16} = \frac{(-223)^2}{16} = \frac{49729}{16} = 3108.0625$$

(Differences)

$$C_1 = \frac{(-81)^2}{96} = \frac{6561}{96} = 68.3437$$

$$C_2 = \frac{(54)^2}{48} = \frac{2916}{48} = 60.750$$

$$C_3 = \frac{(-74)^2}{16} = \frac{5476}{16} = 342.250$$

COMPUTATIONS OF SUMS OF SQUARES

(Post-Test)

$$\underline{\text{SS Group}} = \frac{956^2 + 1761^2}{16} - \frac{2727^2}{32}$$

$$= \frac{4015057}{16} - \frac{7382089}{32} = 20250.78$$

$$\underline{\text{SS Attitude}} = \frac{546^2 + 605^2 + 828^2 + 738^2}{8} - \frac{2717^2}{32} = 6105.84$$

$$\underline{\text{SS Group x Attitude}} = \frac{188^2 + 179^2 + 277^2 + 312^2 + 358^2}{4} +$$

$$\frac{426^2 + 551^2 + 426^2}{4} - \frac{2717^2}{32}$$

- SS Group - SS Attitude = 1996.85

(Differences)

$$\underline{\text{SS Group}} = \frac{1345^2 + 1542^2}{16} - \frac{2887^2}{32} = 1212.78$$

$$\underline{\text{SS Attitude}} = \frac{742^2 + 669^2 + 743^2 + 733^2}{8} - \frac{2887^2}{32} = 471.34$$

$$\underline{\text{SS Group x Attitude}} = \frac{386^2 + 271^2 + 303^2 + 385^2 + 356^2}{4} +$$

$$\frac{398^2 + 440^2 + 348^2}{4} - \frac{2887^2}{32}$$

$$- \text{SS Group} - \text{SS Attitude} = 3433.10$$

(Post-Test)

$$\underline{\text{SS Total}} = X^2 - \frac{(X)^2}{N}$$

$$= 98^2 + 17^2 + 116^2 .... + 106^2 + 148^2 + 101^2 - \frac{(2717)^2}{32}$$

$$= 45910.72$$

(Differences)

$$\underline{\text{SS Total}} = 93^2 + 66^2 + 98^2 ....+ 94^2 + 114^2 + 84^2 - \frac{(2887)^2}{32}$$

$$= 14667.47$$

(Post-Test)

SS Error = SS Total - SS Group - SS Attitude - SS G x A

= 45910.72 - 20250.78 - 6105.84 - 1996.85

= 17557.25

(Differences)

SS Error = 14667.47 - 1212.78 - 471.34 - 3433.10

= 9550.25

ANALYSIS OF VARIANCE

(Post-Test)

Source	df	Sum of Squares	Mean Squares	F
Total	31	45910.72		
Groups	1	20250.78	20250.78	27.68*
Attitude	3	6105.84	2035.28	2.78
C_1 (A_1 vs. $A_2A_3A_4$)	1	2959.26	2959.26	4.05
C_2 (A_4 vs. A_2A_3)	1	38.52	38.52	0.05
C_3 (A_2 vs. A_3)	1	3108.06	3108.06	4.25
Groups x Attitude	3	1996.85	665.62	0.91
Students Within Cells (error)	24	17557.25	731.55	

ANALYSIS OF VARIANCE

(Differences)

Source	df	Sum of Squares	Mean Squares	F
Total	31	14667.47		
Groups	1	1212.78	1212.78	3.06
Attitude	3	471.34	157.11	0.39
C_1 (A_1 vs. $A_2A_3A_4$)	1	68.34	68.34	0.17
C_2 (A_4 vs. A_2A_3)	1	60.75	60.75	0.15
C_3 (A_2 vs. A_3)	1	342.25	342.25	0.86
Groups x Attitude	3	3433.10	1144.37	2.88
Students Within Cells (error)	24	9550.25	397.92	